Lecture 1

Introduction to Analog and Digital Integrated Circuits

March 2, 2005

Prof. SeongHwan Cho

Course Overview

Lecturer

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Course Overview

Teaching Assistant

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권구덕	**LG홀 2103호**	**869-8033,**	**dong81@dimple.kaist.ac.kr**

Course Format

- **Lectures** : Mon / Wed 13:00 ~ 14:20 pm

- **Textbook**
  Required : Sedra, Microelectronic Circuits, 5th Edition
  Provisional : Razavi, Design of Analog CMOS Integrated Circuits
  Optional : Johns & Martin, Analog Integrated Circuit Design

- **Grading**

Homework	20%
Midterm exam	30%
Final exam	40%
Quizzes	10%
Participation	+α%

- **Website: http://web.kaist.ac.kr/~chosta/lecture.htm**

Homework Policy

- Collaboration in homework is accepted but limited to less than two problems. If you collaborate, you MUST identify on the problem who you collaborated with and the details of collaboration. Evidence of collaboration without acknowledgement will be considered "**cheating**" and will not only result in **zero points** for the homework but will also affect your final grade.

- 10% will be deducted for late homeworks for each day it is overdue.

Course Schedule (Tentative)

- **1st half**

Overview, ADC	one week
Device Basics, Single-ended Amplifiers	one week
Current Sources, Differential Amplifiers	two weeks
Frequency Response	one week
Feedback	two weeks

- **2nd half**

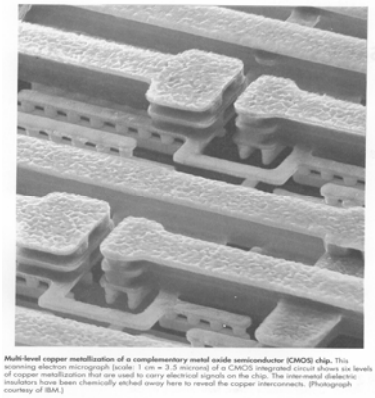
Operational Amplifiers	two weeks
Switch-Capacitor Circuits	one week
Data converters & Filters	one week
Digital Circuits	one week
Signal Generators	one week
TBD	one week

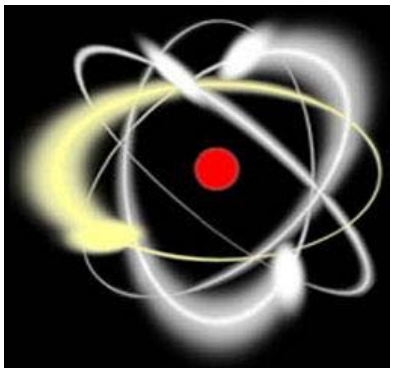
Outline

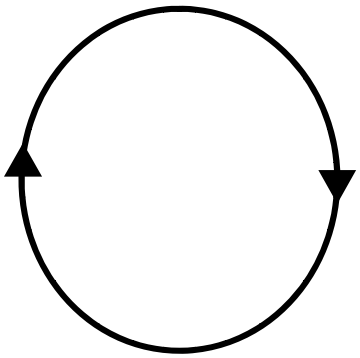
- **Microelectronics Circuits?**
- **History of Information Processing**
- **Analog vs. Digital**

Microelectronic Circuits

Micro Electronic Circuits







Microelectronic circuit is the fundamental basis for the most efficient and comprehensive information processing method that human has ever created !

Why micro-electronic circuits?

– Most efficient way of calculation that human ever created.

– The whole world is surrounded by electric circuits, *integrated circuits* in particular.

Must learn the thought process

Energy
220V outlet
Chemical Battery
Hybrid Cars

Entertainment & Media
TV, DMB
MP3, DVD

Communication
TV
Cellular phones
LAN

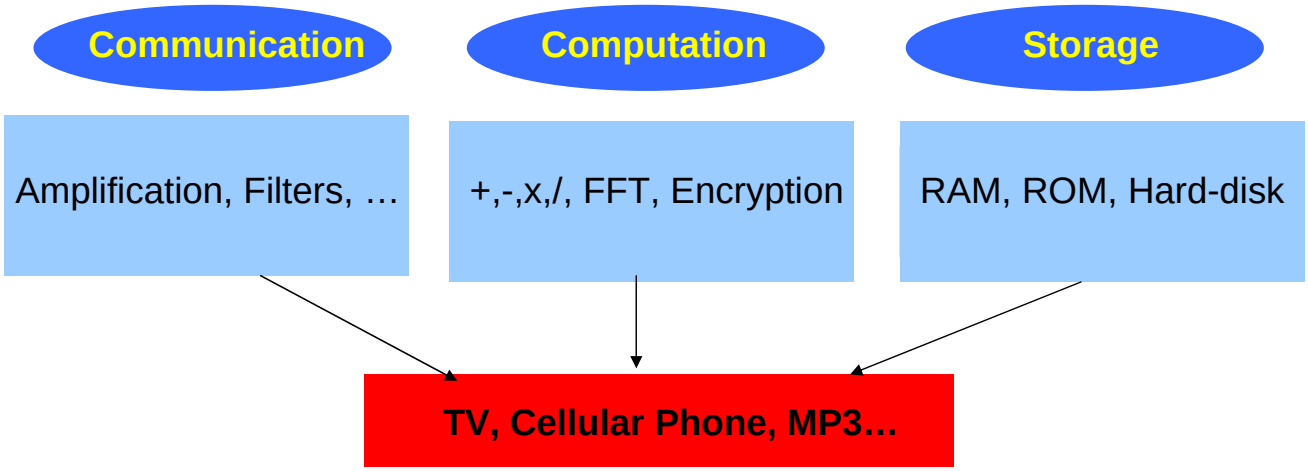
Computation/Storage
PCs, Workstations
RAM, Magnetic Disks

Transportation/industry
Control devices

Why Microelectronic Circuits?

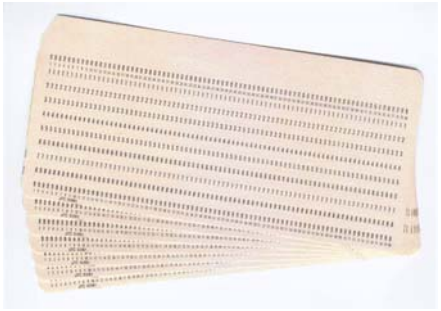
Information processing is key !

How do we process information ?

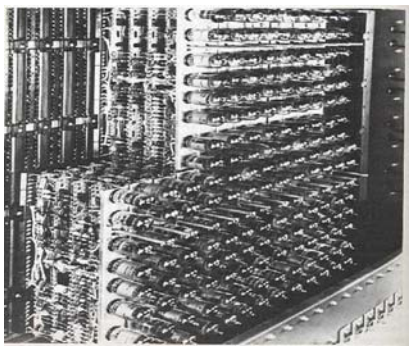


Computing Methods

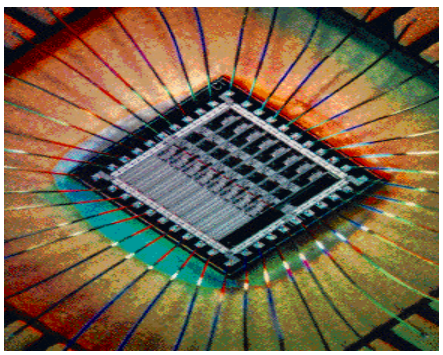
B. C.



19C – 20C

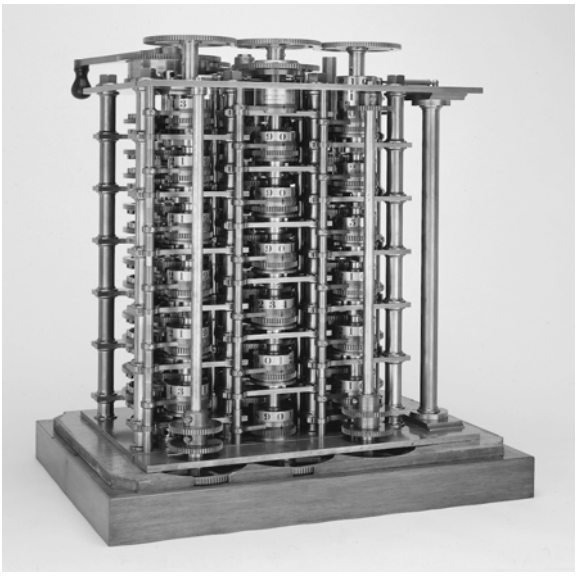


Mid 20C



1980s ~

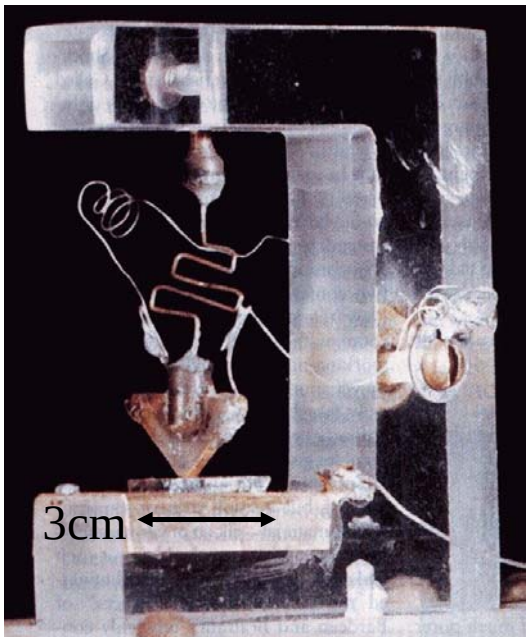
History of Computing



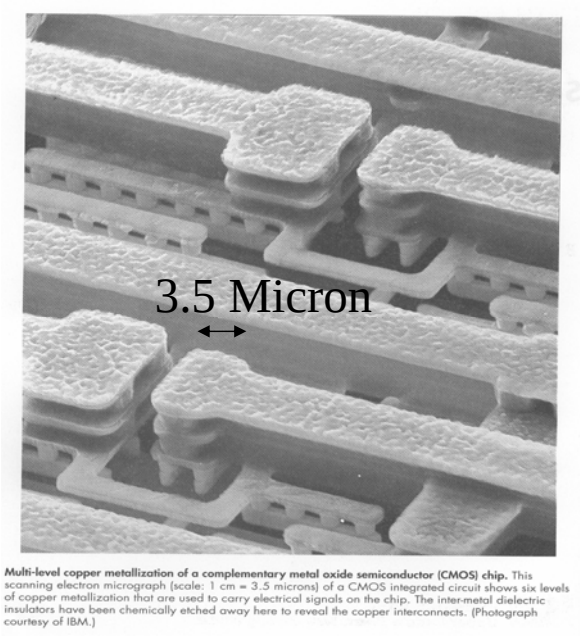
Babbage (1832)
Mechanical Difference Engine 25,000 parts

ENIAC (1946)
World's first electric computer

Integrated Circuit



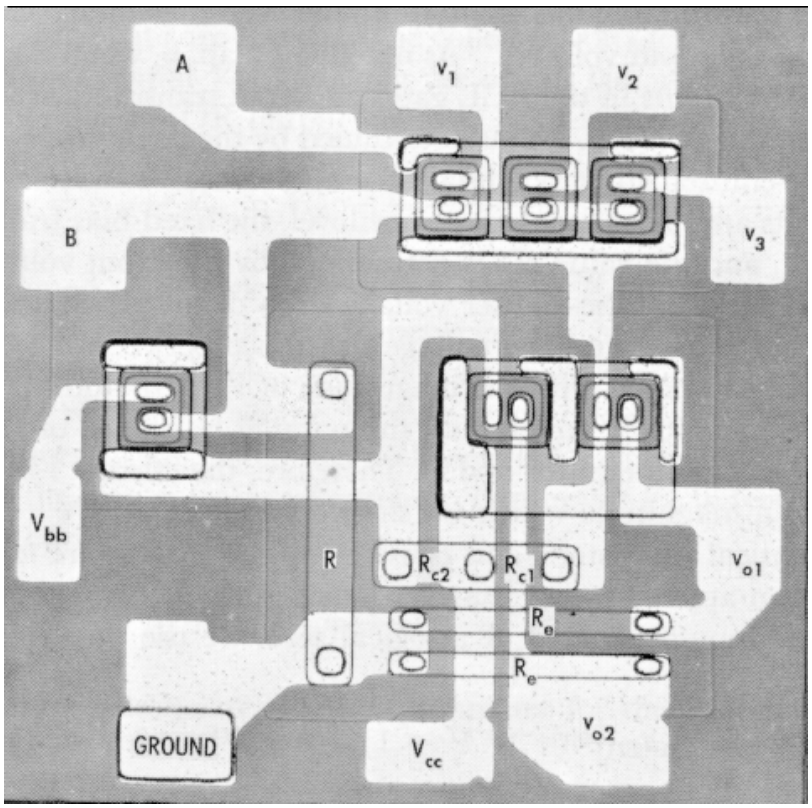
First transistor (1948)
Bell Labs



Multi-level copper metallization of a complementary metal oxide semiconductor (CMOS) chip. This scanning electron micrograph (scale: 1 cm = 3.5 microns) of a CMOS integrated circuit shows six levels of copper metallization that are used to carry electrical signals on the chip. The inter-metal dielectric insulators have been chemically etched away here to reveal the copper interconnects. (Photograph courtesy of IBM.)

Advanced Transistor (2002)
IBM

First Integrated Circuit



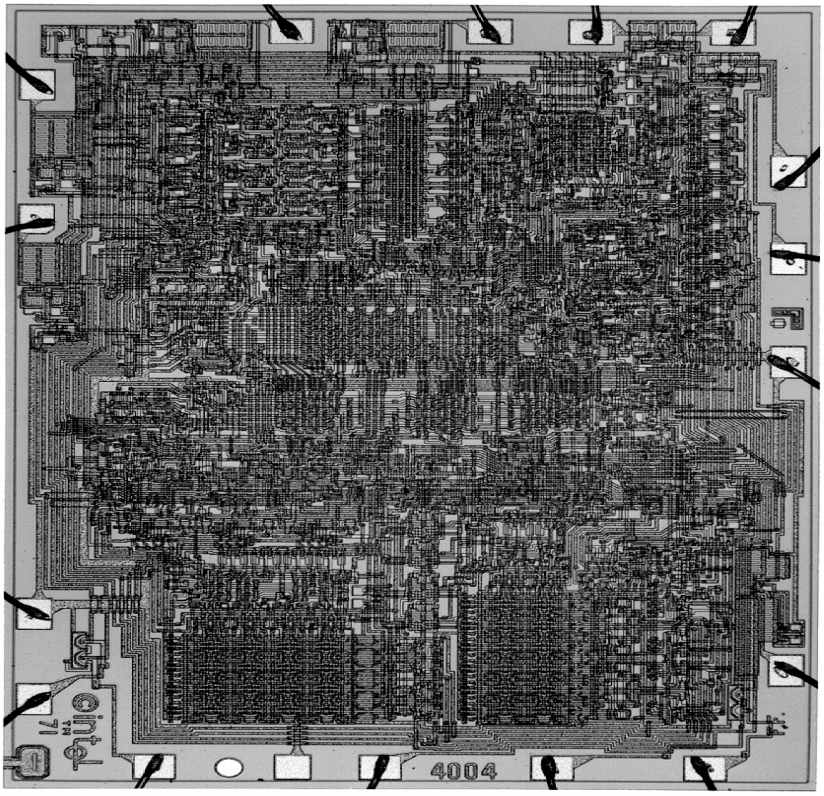
Bipolar logic

1960's

ECL 3-input Gate

Motorola (1966)

Intel 4004 Microprocessor

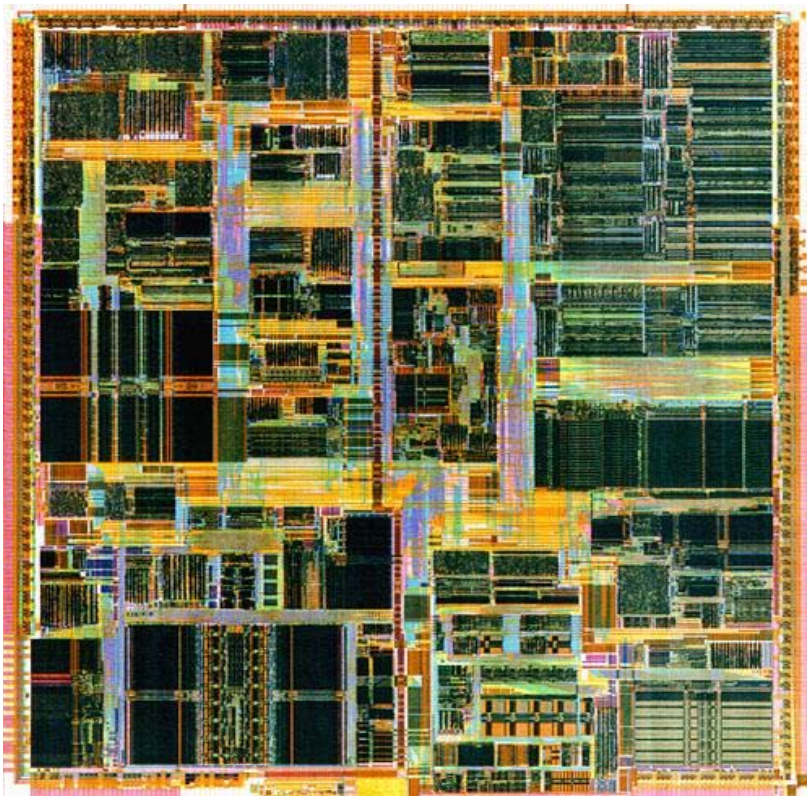


1000 transistors

1 MHz operation

(1971)

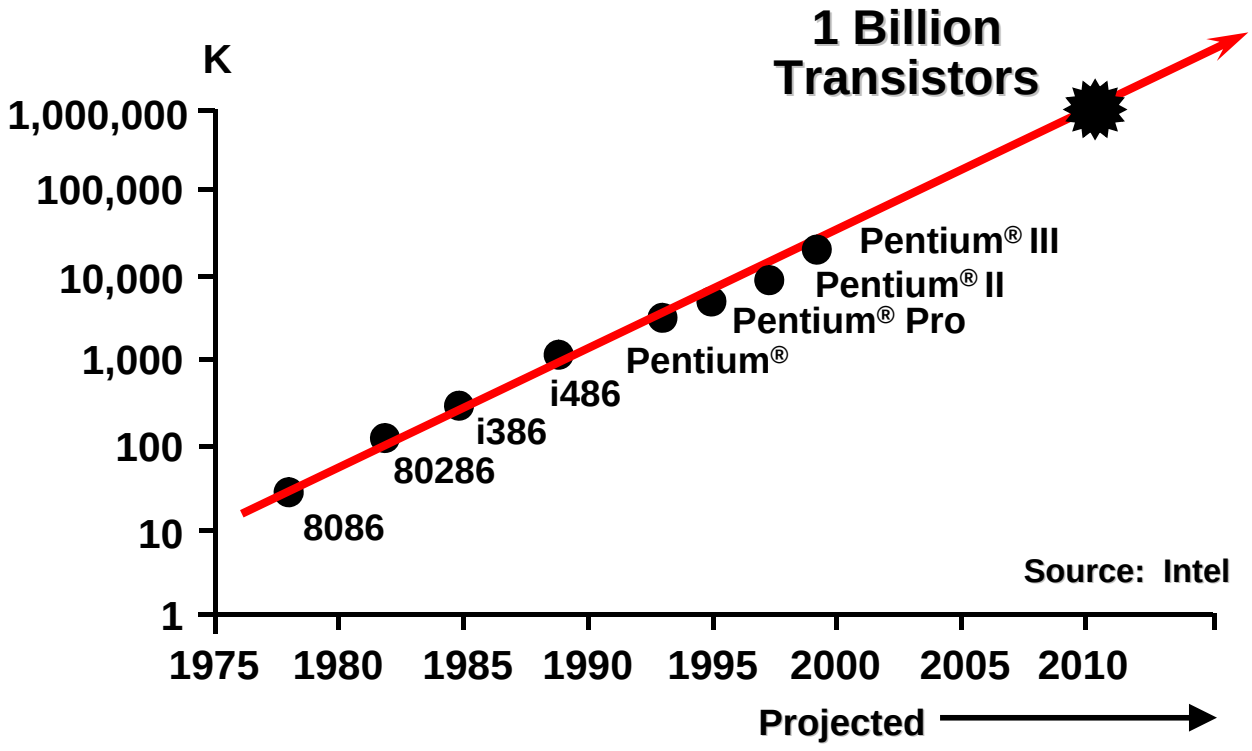
Intel Pentium IV Microprocessor



1 billion transistors

3 GHz Operation

Evolution of Computing



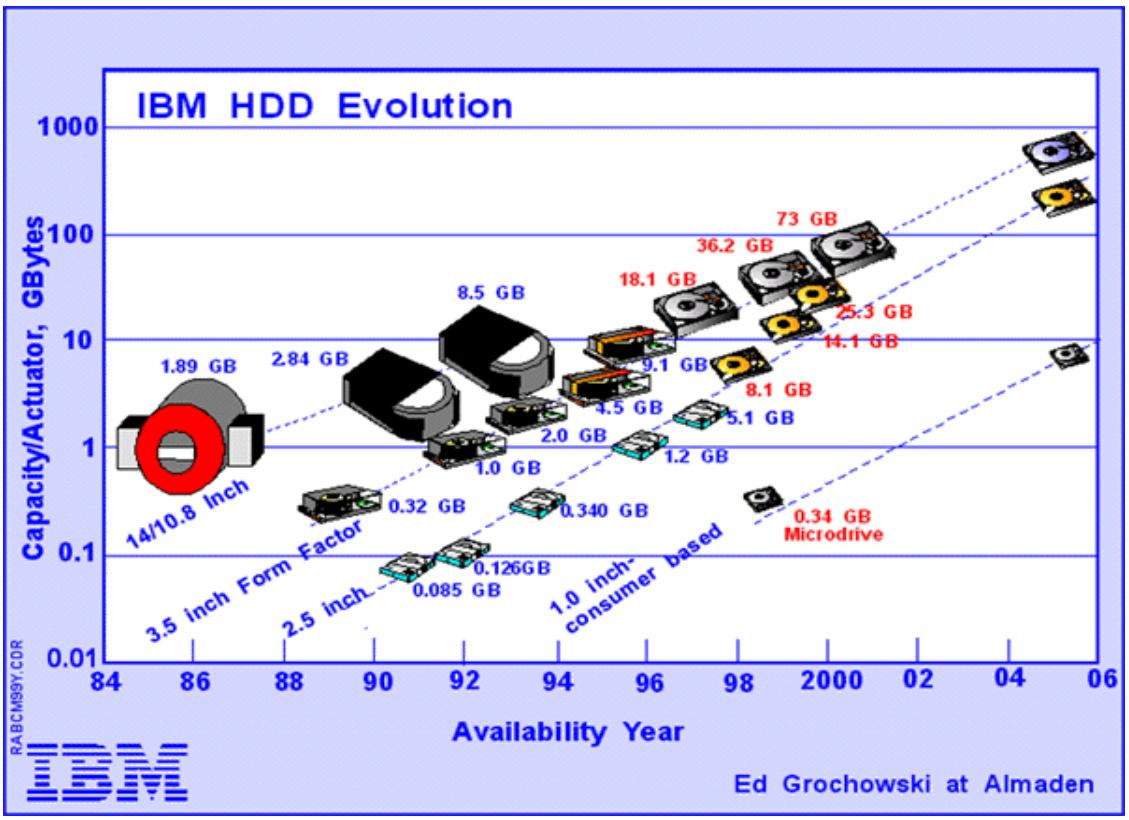
Evolution of Storage

Hard-drives first appeared in 1957.

IBM RAMAC 350 : 50 24” disks
5MB of data
$35,000 per year to lease

First 5.25” disks
5 ~ 10MB
$10,000

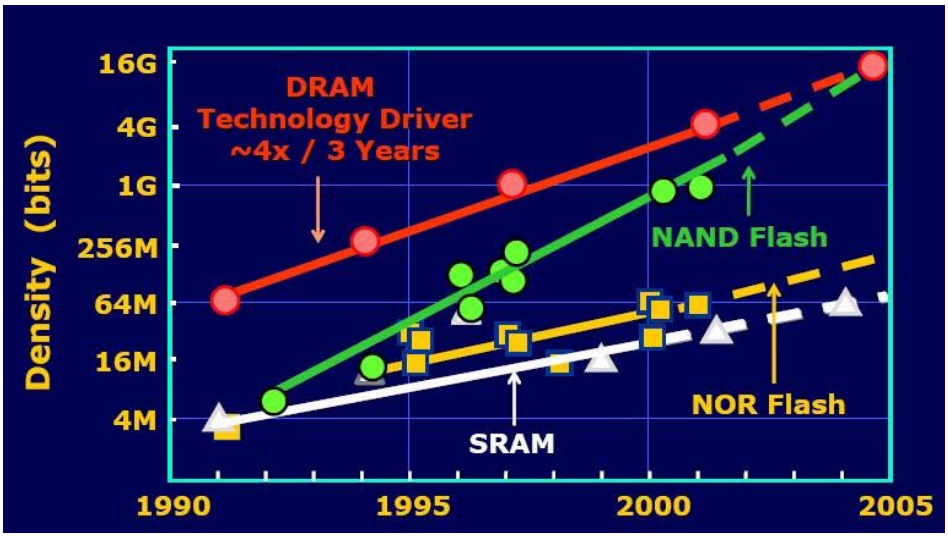
HDD Evolution



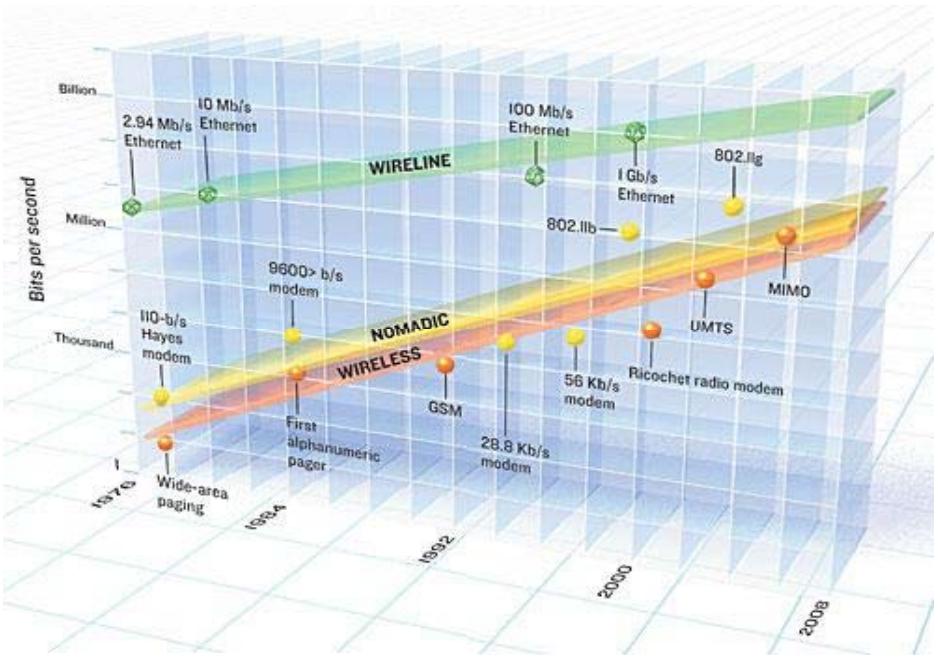
Evolution of Memory

DRAM trends

- $ / bit decreasing at 26% / year (64MB DRAM < $250 in 98)
- Size increasing at rate of 60% / year
- ~10% year decrease for access time.



Evolution of Communication



TELECOM RULES : Wire line, nomadic, and wireless technologies improve in a manner reminiscent of Moore's Law. Soon, even slower communications channels like cellophanes and radio modems will eclipse the capacity of early Ethernet, thanks to upcoming standards known as UMTS and MIMO, which will boost bandwidth by maximizing antenna usage. [Time axis shows dates of first use.]

Digital World

More Digital parts being added.

➔ Is the analog world dying?

Digital World

Analog information processing

→ Digital information processing

(E.g. Phonograph → CD, Laser Disc → DVD)

Digital World

Why Digital Computation and Memory?

Process scaling is MUCH more favorable to digital circuits to analog circuits.

Analog Circuit Necessary?

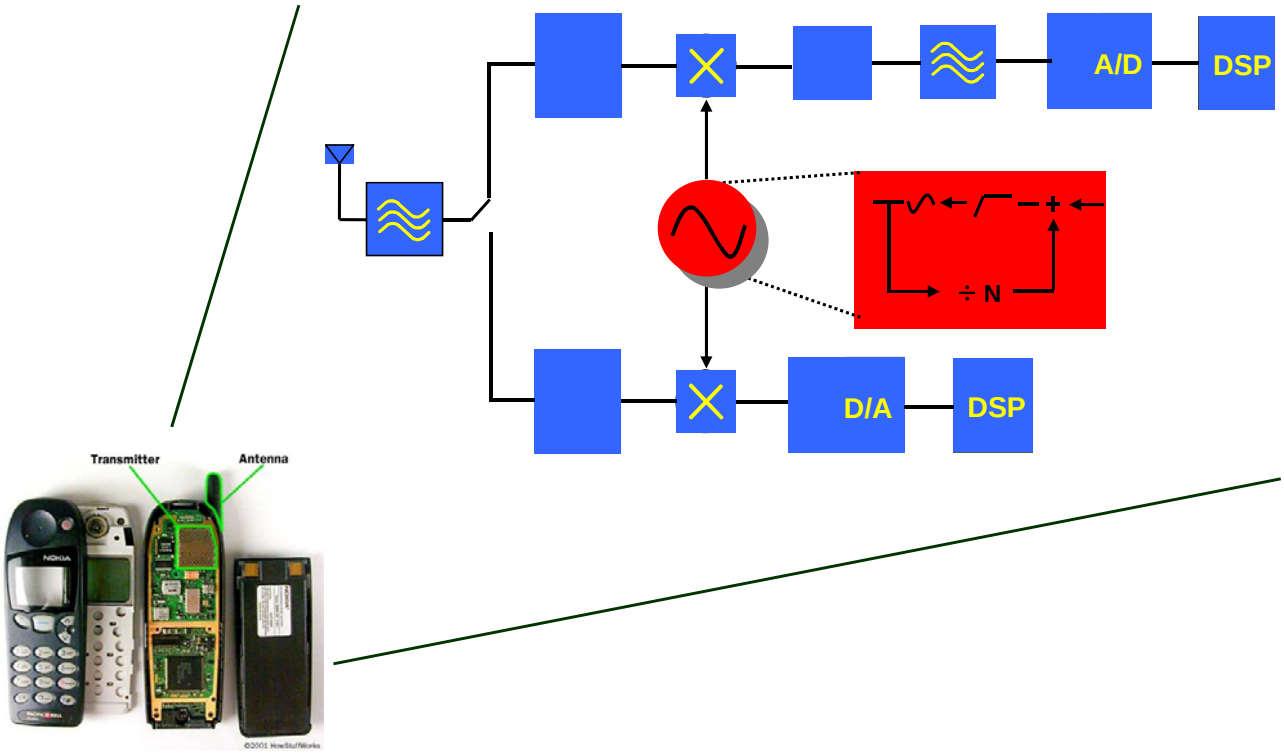
As the capacity of digital computation and memory increases, analog circuits are even more crucial.

Much of the bottleneck lies in the analog circuit technique.

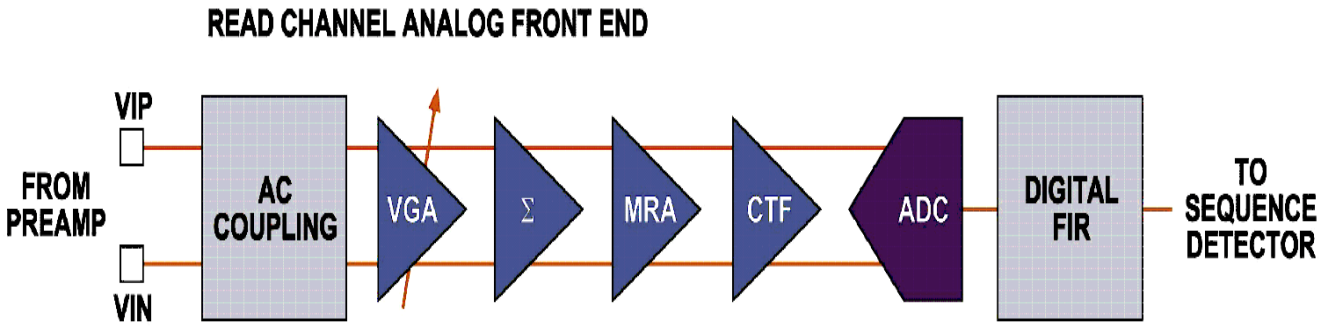
Is Analog Dying?

- Digital is good for computation, communication and storage.
- However there is no such thing as ‘digital’
- Analog-to-digital converter is essential
- Analog serves the digital master

Cellular Phone

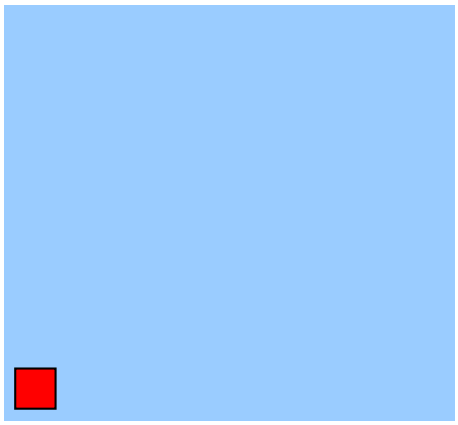


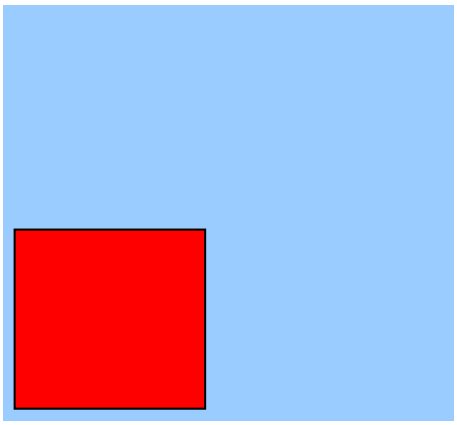
Hard-disk



Applications of Analog Circuits

- Analog-to-digital converters
- High speed serial interface (mixed-signal)
- Frequency synthesizer, VCO, mixers (RF), …





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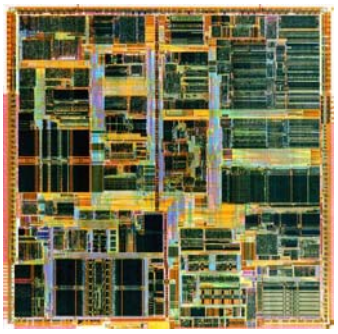


Pentium 4: $200

~ 200mm^2

ADC: $120

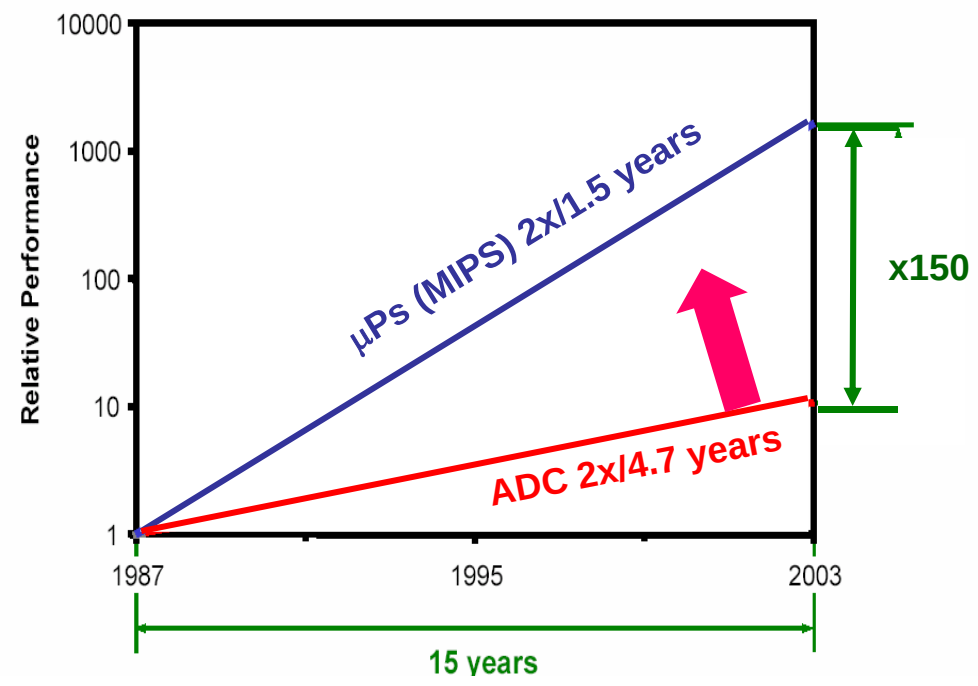
~ 20mm^2

Clock Gen: $15

~ 1mm^2

Analog will never go away!

Performance of analog circuits are critical to system performance!



Performance bottleneck lies in the analog circuits !

Why Microelectronics Circuits?

- **Analog and digital circuits rule the world.**

- **Learn the thought process!**